Novel n-Type Ultrananocrystalline Diamond (UNCD) Electronics

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Diamond has outstanding properties not only for high-performance electronics, but for producing subsequent devices which are bio-compatible and chemically inert. UNCD has significant tribological properties which are ideal for MEMS devices; the ability to fabricate electronic devices with the same materials and fabrication steps would enable fully bio-compatible diamond MEMS devices with onboard electronics, a significant breakthrough.

Real-world diamond electronics will only be possible with the advent of affordable, true CMOS diamond devices, requiring both p-type and n-type electronic diamond materials. Here we demonstrate *n-type* diamond devices using nitrogen doped UNCD, which uses only affordable materials and scalable growth methods. The optimization of n-type MISFET devices is ongoing, and, p/n junction devices will be produced in the near future via further control of the gas chemistry during film growth.

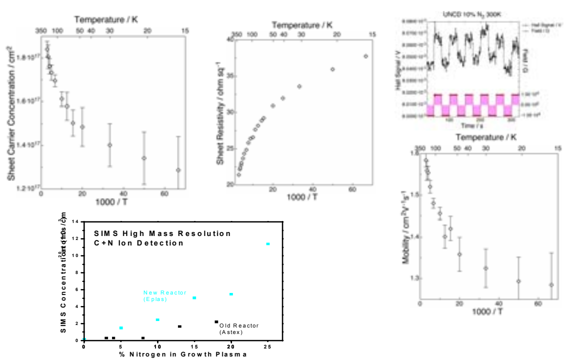
Electronic Requirements:

1. *Film with suitable electronic properties*
2. *Ohmic contacts*
3. *Oxide formation or Schottky contacts*
4. *Device isolation*

N-UNCD Electrical Properties:

- N doping: n-type *semi-metallic*
- The conductivity is a strong function of % N in plasma
- [N] in film < 1at%
- Proposed mechanism: Grain boundary conduction, not substitutional doping or hopping

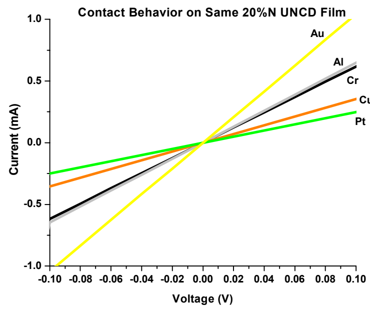
Hall Effect: new results (field-switching setup)

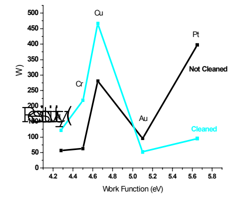


Materials Integration: Oxide Deposition

Both AlO2 and BST [$(Ba_{0.5}Sr_{0.5})TiO_3$] have been successfully integrated with UNCD as gate oxides; work continues on using hydrogen doped UNCD as a gate oxide for a fully UNCD device.

Materials Integration: Metallic Contact Behavior





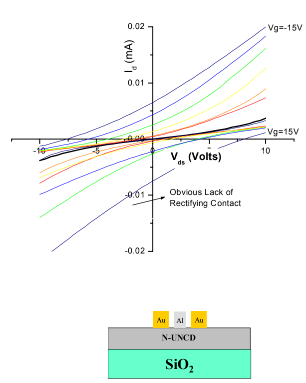
***All* Metal Contacts are Ohmic!**

- Resistance has no dependence on work function or electronegativity
- No effects due to "cleaning" steps or plasma treatments

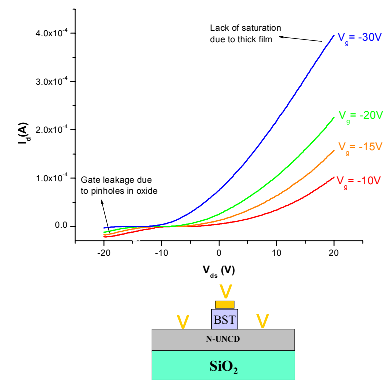
- *High Number of Electrically Active Surface States*
- *Devices possible w/oxide structures*

First N-type Diamond Device: MISFET

MESFET



MISFET



Above: hadow masking: large feature sizes, thick UNCD films

Future/Ongoing: thin layered N-UNCD/H-UNCD structures to achieve turn-off, and traditional fabrication to optimize performance

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